Calculation By: M. Adamowski
Checked By:
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Estimate of time for LAPD tank to achieve 1 psig rise with no cooling:

This calculation estimates the time for the LAPD tank pressure to rise 1 psi.

Argon Data

Argon physical properties from NIST REFPROP

Argon Liquid Density

$$Ldens_{Ar} := 1395 \cdot \frac{kg}{m^3}$$

Argon Heat of Vaporization

$$Hvap_{Ar} := 161 \cdot \frac{kJ}{kg}$$

Argon MW

$$MW_{Ar} := 39.95 \cdot \left(\frac{gm}{mole}\right)$$

Nitrogen Data

Nitrogen physical properties from NIST REFPROP

Nitrogen Liquid Density

$$Ldens_{N2} := 807 \cdot \frac{kg}{m^3}$$

Nitrogen Heat of Vaporization

$$Hvap_{N2} := 199 \cdot \frac{kJ}{kg}$$

Heat Absorbtion rate for the LAPD Tank (from separate calc)

$$Heat_{rate} := 2 \cdot 2106 \cdot W = 4212 \cdot W$$

Calc of time to build pressure without condenser

Argon Vapor space

$$Vap_{sp} := 980 \cdot gal + 1 \cdot ft \cdot \pi \cdot \left(10 \cdot \frac{ft}{2}\right)^2 = 1568 \cdot gal$$

980 gallons is approximate volume of a 10 ft diameter elliptical head.

Tank Normal Pressure

$$P_1 := 1.0 \cdot psi + atm$$

Tank Temperature

$$T_{Ar} := 88 \cdot K$$

Tank Pressure Rise

$$P_{rise} := 1 \cdot psi$$

Amount of vaporized Argon for Pressure rise

$$Vaporized_{Ar} := \left[\frac{\left(P_1 + P_{rise}\right) \cdot Vap_{sp}}{R_g \cdot T_{Ar}} - \frac{P_1 \cdot Vap_{sp}}{R_g \cdot T_{Ar}}\right] \cdot MW_{Ar} = 2.2\,kg$$

Time to Achieve Pressure Rise With no Cooling

$$Time_{op} := \frac{Vaporized_{Ar} \cdot Hvap_{Ar}}{Heat_{rate}} = 1.4 \cdot min$$

Calc of Time for Pressure drop Condenser coil 1 has excess N2

Tank Pressure Drop

$P_{drop} := 1 \cdot psi$

HX Available Areas

$HX\_coil1_{area} := 3 \cdot ft^2$

$HX\_coil2_{area} := 1 \cdot ft^2$

$HX\_coil3_{area} := 4 \cdot ft^2$

Overall U

$U := 200 \cdot \frac{BTU}{hr \cdot ft^2 \cdot R}$

Amount of condensed Argon for Pressure Drop

$$Cond_{Ar} := \left[\frac{P_1 \cdot Vap_{sp}}{R_g \cdot T_{Ar}} - \frac{(P_1 - P_{drop}) \cdot Vap_{sp}}{R_g \cdot T_{Ar}} \right] \cdot MW_{Ar} = 2.2 kg$$

Available Cooling with excess N2 Flow

$Q_{coil1} := HX\_coil1_{area} \cdot U \cdot (88 \cdot K - 78 \cdot K)$ $\qquad Q_{coil1} = 3165 \cdot W$

$Q_{coil2} := HX\_coil2_{area} \cdot U \cdot (88 \cdot K - 78 \cdot K)$ $\qquad Q_{coil2} = 1055 \cdot W$

$Q_{coil3} := HX\_coil3_{area} \cdot U \cdot (88 \cdot K - 78 \cdot K)$ $\qquad Q_{coil3} = 4220 \cdot W$

Time to Achieve Tank Pressure Drop With Excess N2 Flow

With coil 1 only

$$Time_{vac1} := \frac{Cond_{Ar} \cdot Hvap_{Ar}}{Q_{coil1} - Heat_{rate}} = -6 \cdot min$$

Coil 1 alone cannot cause drop in LAPD tank pressure.

With coil 1 and 2 only

$$Time_{vac12} := \frac{Cond_{Ar} \cdot Hvap_{Ar}}{(Q_{coil1} + Q_{coil2}) - Heat_{rate}} = 728.9 \cdot min$$

Coil 1 & 2 can cause drop in LAPD tank pressure over long time.

With coil 1, 2 and 3

$$Time_{vac123} := \frac{Cond_{Ar} \cdot Hvap_{Ar}}{(Q_{coil1} + Q_{coil2} + Q_{coil3}) - Heat_{rate}} = 1.4 \cdot min$$

Coil 1, 2 & 3 can cause drop in LAPD tank pressure in short time.